Stripper Well Consortium
Vortex Flow, LLC Technical Progress Report
Final Report

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"Flowline Grant"

Overview: The scope of our project was to install nineteen of Vortex SX tools in the well flowlines in operating wells in the Michigan and Appalachian basins in order to determine if the tools could assist in reducing flowline backpressure and increase realized production. All wells included in the trials were owned and operated by Belden and Blake.

We installed twelve Vortex SX tools in wells in the Michigan Basin. All installations were made at a point just after the wellhead and at the beginning of a pipe run to the water separator. Since individual well measurements were NOT available, the tools were installed in all wells in a well "pod" for which production data (including historical data) was available.

Additionally, seven units were installed at wells in the Appalachian Basin using the same basic positioning of the tool in the flowline. (an additional three units, not paid for by grant monies, were included in the data collection and reduction).

After installation, actual production was measured and compared to agreed decline curves to determine if a statistically significant increase could be found. Other related anecdotal data such as increased water flow or lower flowline pressures (where they could be measured) were also captured.

Hypothesis:

The project was based on the theory that the unique flow regime created by the Vortex Flow SX tools would be able to reduce flow line backpressure felt by the well by either moving accumulated fluids downstream or by improving overall flow organization. The flow created by the Vortex Flow SX units is depicted in Figure 1.

Figure 1 – Diagram of flow created by Vortex Flow SX unit.

Hypothesis – Continued: If we were successful in reducing flow line backpressure, we could effectively lower well bottom hole pressure as indicated by the changing conditions in Figures 2 and 3. Using Vogel's Inflow Performance Relationship Curve (Figure 4), we hypothesized that the reduced bottom hole pressure would result in increased production.

Figure 2 – Typical System Pressure Diagram Before Vortex Flow SX Tool Installation

Production Quantity = Permeability * (Reservoir Pressure – Downhole Pressure)

Bottom Hole Pressure = **Surface Pressure** + **Friction** + **Head**

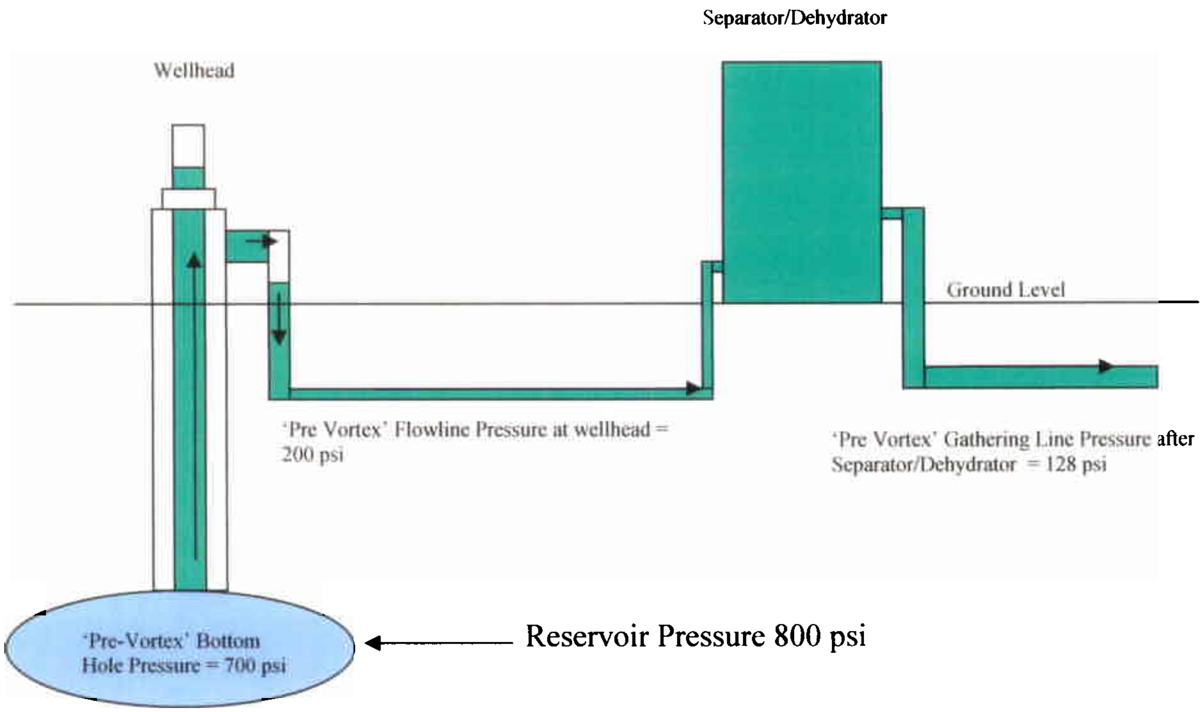


Figure 3 -Typical System Pressure Diagram After Vortex Flow SX Tool Installation

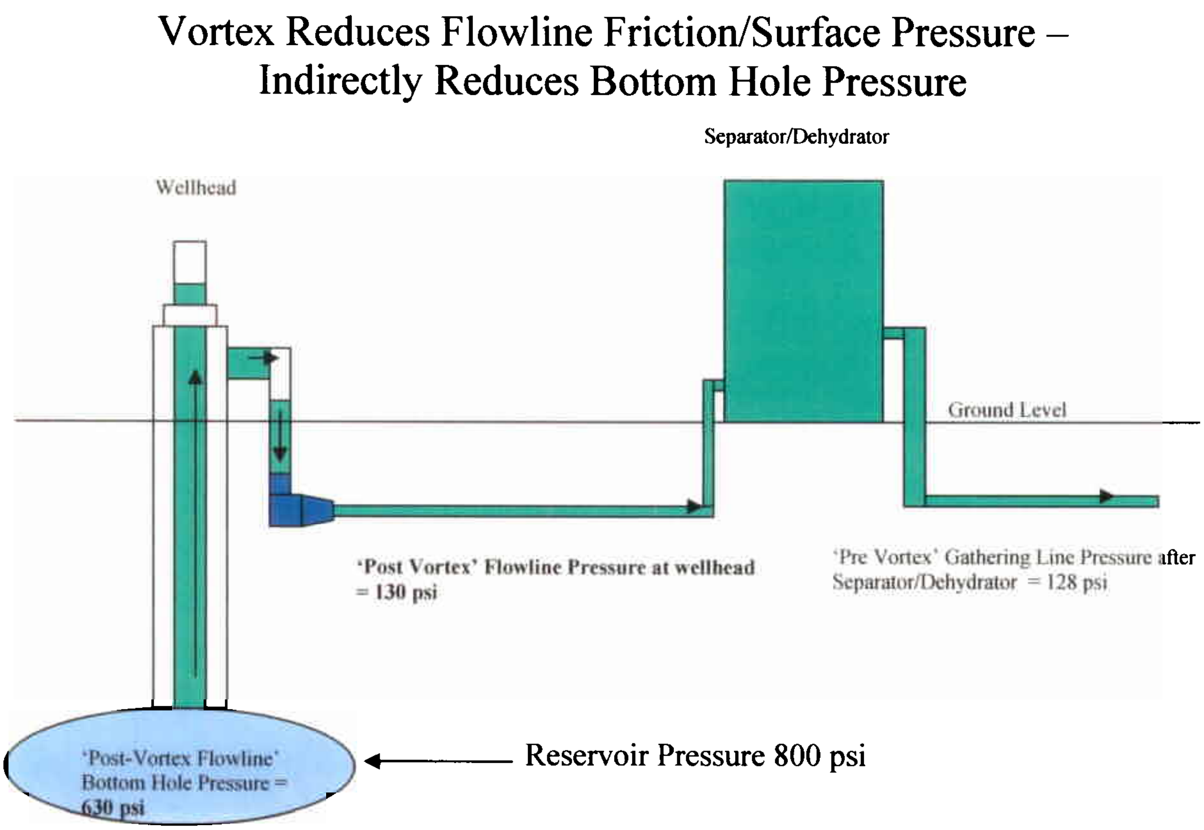
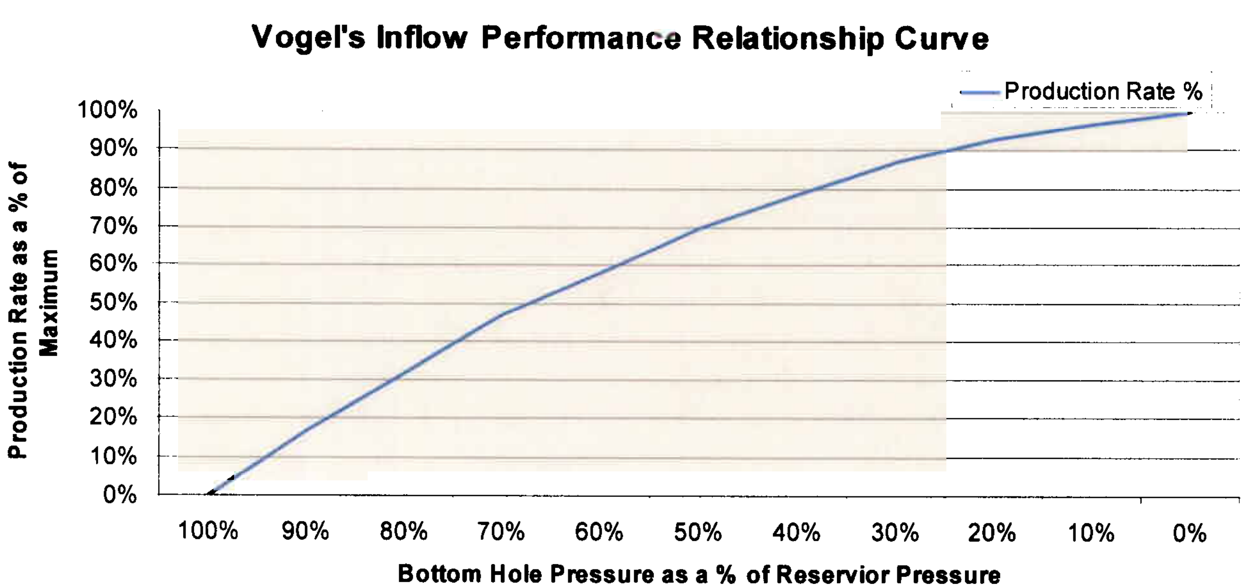


Figure 4 – Vogel's Inflow Performance Relationship Curve



Experimental Apparatus: Standard Vortex 2", 2 ½" and 3" SX units were used in the tests. All of the units were installed within 20 feet of the wellhead at a point just after the wellhead on the run to the water separator (or pod water separator). Additional well information and tool technical specifications are included below.

General Well Specifications:

Basin	**Operating Pressures**	**Production**
Appalachian	50 – 15- p.s.i.	10 – 125 MCFD
Michigan	1 – 15 p.s.i.	50 – 80 MCFD

Michigan Basin Well Information:

Basin:	Michigan
Formation Type:	Antrim Shale
Well Age:	5 years +
Well Type:	Rod Pump
Flowline Size:	2"
Flowline Length:	500 feet to 8,000 feet - depending on well
Vortex VX Install:	At surface just after wellhead

Appalachian Basin Well Information:

Basin:	Appalachian
Well Age:	2 to 7 years
Well Type:	Flowing
Flowline Size:	2", 2 1/2" and 3"
Flowline Length:	500 feet to 2,000 feet - depending on well
Vortex VX Install:	At surface just after wellhead

Technical Specifications – Vortex Flow SX Tools

Pipe Steel:	ANSI Schedule 40
Back Plate:	A36 Grade Steel
Weld Specification:	ASME B31.3
Tool Hydrotesting:	To 700 p.s.i or greater
Connection:	Threaded
Interior Coating:	None

Michigan Basin Installations:

The Vortex SX units were installed on the wells in late July, 2002. Each installation took approximately 2 hours. In the subject wells, a rod pump is used to pump water up the tubing while gas is flowed up the casing and then fed in to gas flowlines. Operating pressures for the wells are generally in the range of 6 p.s.i. to 12 p.s.i. with some wells having pressures as low as 1-2 p.s.i.

A significant problem for this system was the "falling out" of water entrained in the gas stream during periods of large temperature swings (primarily fall and spring months). The water that drops out of the gas stream was collecting in the flowlines increasing back pressure and making the system prone to frequents freeze-ups in the very cold Northern Michigan environment.

Appalachian Basin Installations

The Vortex SX units were installed on the wells in late July, 2002. Each installation took approximately 1-2 hours. All wells that received the tools were flowing wells. In all cases the tools were installed in wells that had flow lines that ran directly to a separator or collection point. However, there were several tools that were installed on flow lines that also received production from an additional 1-2 wells upstream in the system along with production from the well on which the tool was installed. We did see improvements in production for wells connected to those that had tools installed but these improvements were not included in the data measurement and reduction.

Experimental and Operating Data:

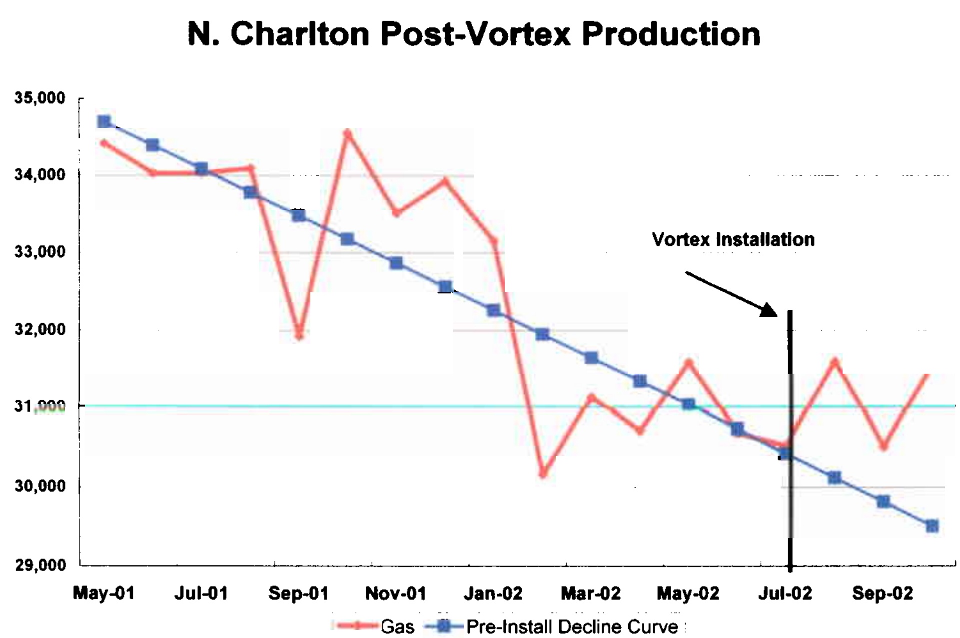
Data Analysis Methodology

1) All 10 wells in the Appalachian Basin test were analyzed individually
2) All 12 wells in the Michigan Basin test pod were analyzed as a single data stream as individual well data was not available.
3) Pre-Installation production data was gathered back to 1996 or when the well went online, whichever was later.
4) Using Actual production data, decline curves were generated and agreed.
5) Agreed decline curves were used as the baseline to measure whether the tools generated any production improvements
6) Five months of post installation data was collected, aggregated and compared to the five month total expected production predicted by the decline curves

Test Results

Data analysis showed a very modest increase in production for the lower pressure Michigan Basin wells (see Figure 5) . A production increase of approximately 5% over the long-term decline curve was noted. There were some small increases in produced water but it was agreed that this was most likely due to movement of some of the water trapped in the flowline to the separator.

Figure 5 – Results From Michigan Basin Vortex SX Installations



Test Results - Continued

In the Appalachian Basin wells, the success rate was much more significant. Table 1 shows the actual and expected production for the 10 wells in the test. In general, production was flat to up as much as 48%. Figures 6 and 7 show the same data in a different method. Figure 6 shows actual pre-installation production as a percentage above or below the decline curve. All data points below 0% indicate production below the decline curve and all data points above 0% indicate production above the decline curve. Figure 7 shows the results from all test wells after the Vortex Flow SX installations.

Table 1 – Results from Vortex Flow SX Tool Installations in the Appalachian Basin

Well Name	Pre Install MCFM	Pre Install MCFD	5 Month Total Predicted by Decline Curve MCF	Actual Production MCF	Difference MCF	Difference
ROGGENKAMP #1	562	18	3,208	3,261	53	1.65%
MCCHESNEY #1	1,792	59	8,873	10,980	2,107	23.75%
COZY #1	396	13	2,075	2,371	296	14.27%
BEAGLE CLUB #1	578	19	2,759	3,585	826	29.93%
MERKLE #1	2,148	71	4,823	5,501	678	14.06%
CHERRY RUN #2	3,792	125	11,503	12,773	1,270	11.04%
GOODWILL #2	2,326	77	6,353	8,542	2,189	34.46%
SEAMANS #1	3,086	102	6,600	9,774	3,174	48.09%
HEATH #2	1,544	51	6,005	6,890	885	14.74%
GOODWILL #3	2,792	92	10,766	11,029	263	2.44%

Figure 6 – Actual Production as a % Over or Under the Agreed Decline Curve

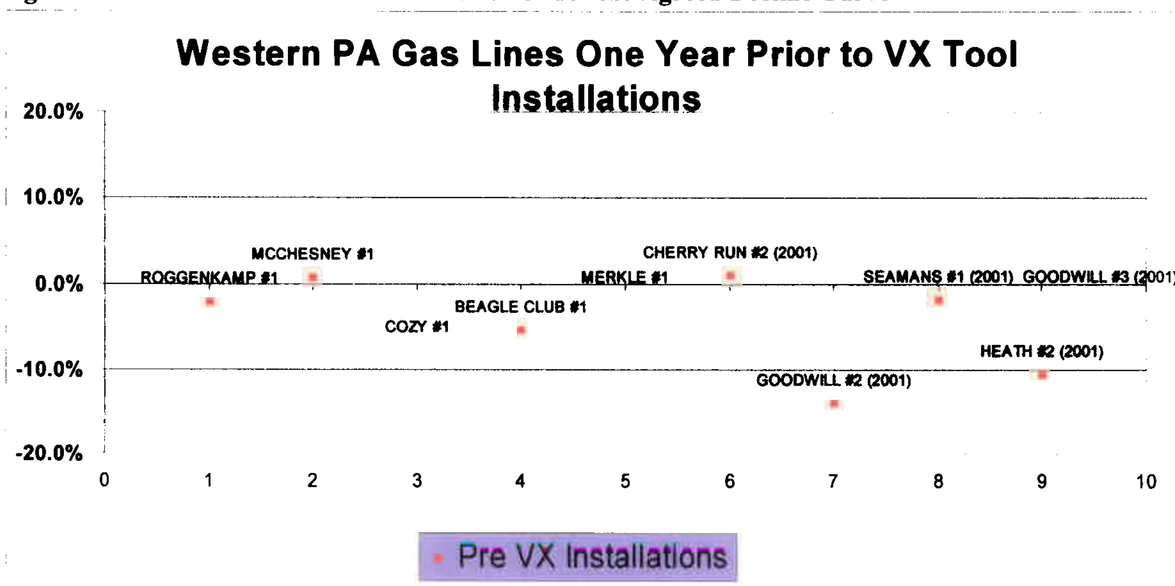
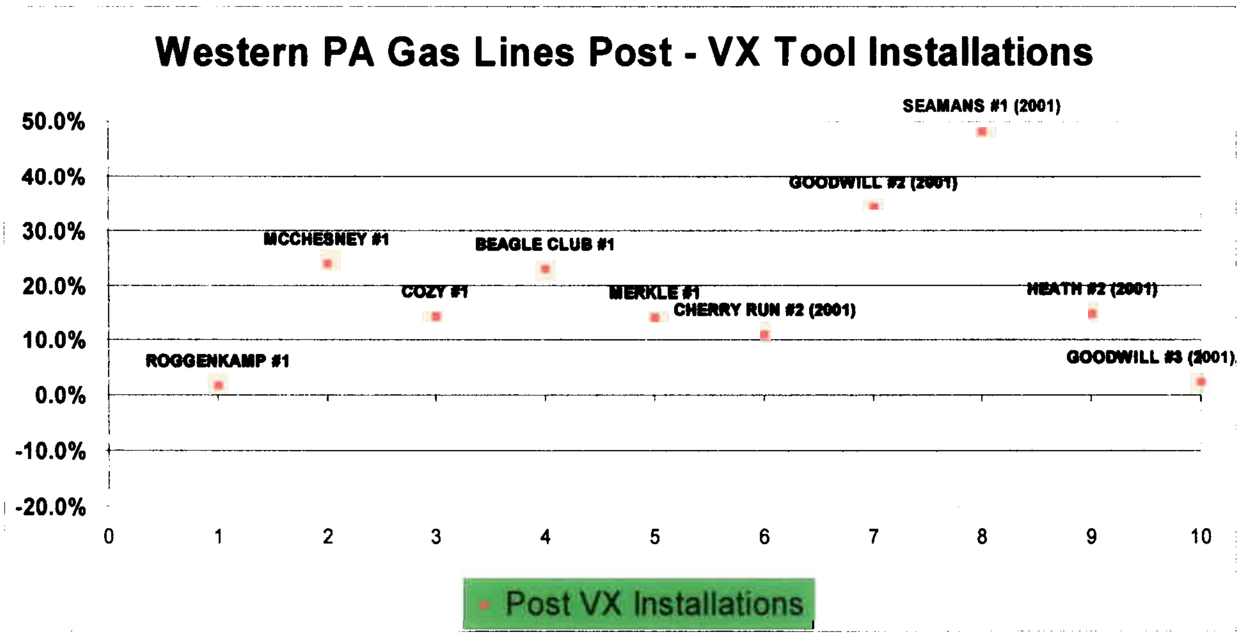


Figure 7 – Actual Production as a % Over or Under the Agreed Decline Curve



Hypothesis and Conclusions: We have drawn the following conclusions based on the results from the tests covered by this grant:

1) The Vortex SX units have the ability to help organize flows in flowlines to making the flow regime more efficient and reducing backpressure experienced by the well. The benefit from this effect varies based on operating pressures.
2) The lower bound operating pressure (or mass flow rate) for the Vortex SX tool to be effective is somewhere above the pressure/flow conditions seen in the Michigan Basin installations. Additionally, formation permeability may also play a role in whether small pressure reductions achieved through use of the technology could be used to increase production and recoverable reserves.
3) The Vortex SX tools are very effective as a tool for increasing production for wells that have higher operating pressures and higher mass flow rates. The tools are a good solution for increasing both production and recoverable reserves by lowering flowline backpressure in these types of installations.